



Procedures and Guidelines

DIRECTIVE NO. 424-PG-7120.2.1
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Title: EOS Chemistry Project Plan

P1. PURPOSE

The purpose of the EOS Chemistry Project Plan is to document how the Project will be managed. As such, it represents a contract between the Project Manager and the Associate Director of Flight Projects for EOS-G for the development, integration, test, calibration, science algorithm development, launch, and operation of the EOS Chemistry spacecraft and its science instruments.

P2. REFERENCE

GPG 1060.1, Management Responsibilities
GPG 1060.2, Management Review and Reporting for Programs and Projects
GPG 7120.2, Project Management
NPG 7120.5, NASA Program and Project Management Processes and Requirements

P3. SCOPE

The Project Plan identifies organizational relationships and responsibilities for the management and technical support through all phases of the system life cycle. It presents the management approach including the organization, Work Breakdown Structure, the review structure and resource requirements. The implementation approach contains a system description, support requirements and facility requirements. The Project Plan is maintained under the Goddard Directives Management System.

P4. DEFINITIONS

None

P5. AUTHORITIES AND RESPONSIBILITIES

As specified in the Plan.

P6. CANCELLATION

None

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Earth Observing System (EOS) Chemistry Project Plan

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P7. QUALITY RECORDS

None

P8. IMPLEMENTATION

The EOS Chemistry Project Manager has overall responsibility for implementation of this Project Plan. This responsibility is described more fully in Sections 4 and 6 of the Plan.

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Earth Observing System (EOS) Chemistry Project Plan

1. INTRODUCTION.....	6
1.1 SUMMARY.....	6
1.2 BACKGROUND.....	6
1.3 INTERCENTER ACTIVITIES.....	7
1.4 PROJECT MANAGEMENT PROCESS.....	7
2. PROJECT OBJECTIVES.....	7
2.1 PROJECT GOALS AND OBJECTIVES.....	7
2.2 PERFORMANCE GOALS.....	8
2.3 PERFORMANCE INDICATORS.....	9
3. CUSTOMER DEFINITION AND ADVOCACY.....	9
3.1 CUSTOMER DEFINITION.....	9
3.2 CUSTOMER ADVOCACY.....	9
4. PROJECT AUTHORITY.....	9
5. TECHNICAL SUMMARY.....	10
5.1 BACKGROUND.....	10
5.2 PROJECT CHARACTERISTICS.....	10
5.3 EOS CHEMISTRY PROJECT LEVEL 1 REQUIREMENTS.....	10
5.3.1 General Level 1 Requirements.....	10
5.3.2 EOS Chemistry Specific Level 1 Requirements.....	13
5.3.3 Instrument Level 1 Requirements.....	14
5.3.4 Observatory System Integration and Test.....	22
6. MANAGEMENT.....	22
6.1 EOS CHEMISTRY PROJECT MANAGEMENT RESPONSIBILITIES AND ORGANIZATION.....	22
6.1.1 EOS Chemistry Project Manager.....	22
6.1.2 EOS Chemistry Deputy Project Manager (DPM).....	23
6.1.3 Deputy Project Manager/Resources (DPM/R).....	23
6.1.4 Project Scientists (910).....	23
6.1.5 Systems Manager (730).....	25
6.1.6 Systems Assurance Manager (303).....	25
6.1.7 Ground System and Operations Manager (423).....	25
6.1.8 Software Systems Manager (582).....	25
6.1.9 Instrument Systems Manager (ISM).....	26
6.1.10 Observatory Manager.....	26
6.1.11 Financial Manager.....	26
6.1.12 Project Support Manager.....	26
6.1.13 Procurement Manager (214.3).....	27
6.2 MANAGEMENT SUPPORT SYSTEMS.....	27
6.2.1 Project Monthly Status Review.....	27
6.2.2 Monthly Coordination Review (MCR).....	27
6.2.3 Monthly Status Review (MSR).....	27
7. SCHEDULES.....	27
8. RESOURCES.....	29

Effective Date: 15 April 1999Expiration Date: N/A

8.1	FUNDING REQUIREMENTS	29
8.2	INSTITUTIONAL REQUIREMENTS	29
9.	CONTROLS.....	29
9.1	CHANGE/CONFIGURATION MANAGEMENT	29
9.2	KEY PROGRAM PARAMETERS	29
9.2.1	Cost Control	30
9.2.2	Schedule Control.....	30
9.3	VERIFICATION OF REQUIREMENTS - CERTIFICATION.....	30
10.	IMPLEMENTATION APPROACH	30
10.1	IMPLEMENTATION APPROACH.....	30
10.1.1	Spacecraft.....	30
10.1.2	Instruments	30
10.2	PROJECT SUMMARY WORK BREAKDOWN STRUCTURE (WBS)	31
11.	ACQUISITION SUMMARY.....	32
12.	PROGRAM/PROJECT DEPENDENCIES	32
12.1	EOS SCIENTIFIC PROGRAM	33
12.2	EOS ALGORITHM ACTIVITIES	33
12.3	EOSDIS.....	33
12.4	EOS FLIGHT PROGRAM.....	33
12.5	EOS PROGRAM INTEGRATION	34
13.	AGREEMENTS.....	34
14.	SYSTEMS ASSURANCE.....	36
14.1	GENERAL	36
14.2	QUALITY ASSURANCE.....	36
14.3	PERFORMANCE VERIFICATION	36
14.3.1	Test and Analysis Program.....	36
14.3.2	End-to-End Compatibility Tests and Simulations.....	37
15.	RISK MANAGEMENT PLAN.....	37
15.1	RISK PROCESS.....	37
15.2	CONTINUOUS RISK MANAGEMENT (CRM) PLAN	37
15.3	CRM IDENTIFICATION	37
15.4	CRM RISK TOOLS	38
16.	ENVIRONMENTAL IMPACT	38
17.	SAFETY	38
17.1	INDUSTRIAL SAFETY	39
17.2	CONTRACTOR'S FACILITIES	39
17.3	DATA SECURITY	39
17.4	REFERENCES.....	39
18.	TECHNOLOGY ASSESSMENT AND COMMERCIALIZATION.....	39
19.	REVIEWS.....	40

19.1	PROGRAM LEVEL REVIEWS.....	40
19.1.1	Independent Annual Review	40
19.2	PROJECT LEVEL REVIEWS	40
19.2.1	Management Coordination Review (MCR)	40
19.2.2	Monthly Status Review (MSR)	40
19.2.3	Project Status Review (PSR).....	40
19.3	MISSION SYSTEMS REVIEWS	40
19.3.1	Spacecraft Reviews	40
19.3.2	Chemistry Instrument Reviews.....	41
19.3.3	Mission Operations Review (MOR)	42
19.3.4	Flight Operations Review (FOR)	42
19.3.5	Operational Readiness Review (ORR)	42
APPENDIX A, ACRONYMS AND ABBREVIATIONS		44
APPENDIX B, APPLICABLE AND REFERENCED DOCUMENTS.....		46

1. INTRODUCTION

1.1 SUMMARY

The overall goal of the Earth Observing System (EOS) Program is to advance the understanding of the entire Earth system on a global scale by improving our knowledge of the components of the system, the interactions between them, and how the Earth system is changing.

The EOS Program mission objectives are:

- To create an integrated scientific observing system emphasizing climate change, that will enable multidisciplinary study of the Earth's critical, life-enabling, interrelated processes involving the atmosphere, oceans, land surface, polar regions, and solid Earth, and the dynamic and energetic interactions among them
- To develop a comprehensive data and information system, including a data retrieval and processing system, to serve the needs of scientists performing an integrated multidisciplinary study of planet Earth and to make Earth System Science data and information publicly available
- To acquire and assemble a global database for remote sensing measurements from space over a decade or more to enable definitive and conclusive studies of Earth system attributes

The Earth Observing System (EOS) Chemistry (CHEM) Project is the project title officially approved by the Earth Science Enterprise (ESE). This effort was funded in Fiscal Years (FY) 1991 and 1992 by Unique Project Number (LPN) 426 (EOS Instruments) and by UPN 228 (EOS Chemistry Series) beginning in FY 1993.

1.2 BACKGROUND

The Chemistry Mission began in 1992 as one of the EOS Science Missions. Over the course of the next several years, the Chemistry Mission underwent a number of major changes that included

- changes in payload complement
- changes in launch vehicle, from IELV (Atlas II type class) to MELV (Delta II type class)
- funding profile and/or run-out cost

After the award of the Common Spacecraft contract in 1995, the Chemistry Project, including the instrument teams, was tasked to study alternative implementation approaches that considered

- reduced cost, size, and schedule
- fly on multiple commercial spacecraft for less than the cost of the Common Spacecraft implementation
- add new technology (beyond that already being developed)
- develop individual PI-mode missions

During an 18-month period, numerous study iterations were conducted. Additionally, during this period TRW (the Common Spacecraft contractor) reduced the cost of the Chemistry Spacecraft development by a substantial amount. This cost reduction was made possible in part by common procurements and a shortened development schedule. Ultimately, the decision was made to proceed with the Common Spacecraft implementation of CHEM. In 1997, the Biennial Review Team, The Inspector General, and the Government Accounting Office all endorsed the decision to fly Chemistry on the Common Spacecraft.

The Common Spacecraft Critical Design Review (CDR) was held in June 1998. Although primarily directed towards the PM payload suite of instruments, this CDR also addressed CHEM requirements.

Because of the Common Spacecraft architecture, the CHEM spacecraft development effort is significantly aided by having PM as a pathfinder. That is, the second copy of the Common Bus being developed by TRW will fly the CHEM payload. This provided the opportunity to reduce risk and cost by procuring and fabricating common CHEM hardware along with the PM hardware. Additionally, the CHEM spacecraft and instrument were able to optimize instrument interface accommodations based on the maturity of the spacecraft design.

1.3 INTERCENTER ACTIVITIES

Two of the four EOS Chemistry instruments, MLS and TES, are being developed by JPL under Intercenter Agreements with suballotted funds.

1.4 PROJECT MANAGEMENT PROCESS

The EOS Chemistry Project employs the Project Management Process as defined in NASA Procedures and Guidelines (NPG) 7120.5A, NASA Program and Project Management Processes and Requirements. Since this Project Plan is being established subsequent to the completion of the Project Formulation and Project Approval Subprocesses, this Plan will focus on the Project Implementation Subprocess.

The EOS Chemistry Project has been operating under the EOS Execution Phase Project Plan, dated May 1995, until now. This new Plan provides a new baseline for the Project implementation Subprocess that reflects redirection from a number of external reviews, programmatic changes, and organizational changes that have occurred.

2. PROJECT OBJECTIVES

2.1 PROJECT GOALS AND OBJECTIVES

The EOS CHEM Project goals are to:

- a. Understand clearly and fully the needs of our customers;

- b. Implement and operate the EOS CHEM Project while providing the greatest possible satisfaction of these needs, within known program and budget constraints; and
- c. Be responsive to changes in the needs of our customers and in program constraints.

The goal of the EOS Chemistry Mission is to study the chemistry and dynamics of the Earth's atmosphere from the ground through the mesosphere. The mission will provide global surveys of several atmospheric constituents which can be classified into anthropogenic sources (CFC types), radicals (e.g., ClO, NO, OH), reservoirs (e.g., HNO, HCl), and tracers (e.g., N₂O, CO₂, H₂O). Temperature, geopotential heights, and aerosol fields will also be mapped. This mission will provide the first global measurements of several important tropospheric chemicals.

To achieve these goals, the EOS CHEM Project adopts the following objectives:

- a. Interact effectively with program management and the science community to specify and develop an observatory and instrument suite which reflects an optimum balance between needs and constraints;
- b. Design, fabricate, integrate, install, and test the CHEM instrument suite on the EOS Common Spacecraft using methods and techniques that 1) assure achieving the documented requirements, 2) guarantee cost and schedule control, and 3) pro-actively manage all significant sources of risk; and
- c. Procure the launch services and support necessary to reach the proper orbit (705 km), checkout of the spacecraft and instruments and turn over to the ESDIS Project.

2.2 PERFORMANCE GOALS

To achieve the above goals and objectives the Chemistry Project has the following performance goals:

- manage the development of four state-of-the-art PI-class instruments that include the High Resolution Dynamics Limb Sounder (HIRDLS), the Microwave Limb Sounder (MLS), the Ozone Monitoring Instrument (OMI), and the Tropospheric Emission Spectrometer (TES)
- manage the development, integration, and test of the Chemistry Observatory, an Earth Observing satellite carrying the four Chemistry instruments into a polar, sun-synchronous, 705 km orbit with a 1:45 pm equatorial crossing time (ascending node) and a 6-year operational goal
- manage the development of the ground and flight operations and control interfaces
- manage the launch, on-orbit checkout, and activation and mission handoff
- provide sustaining engineering for the duration of the mission
- provide science algorithms to the EOS Data and Information System (EOSDIS)
- produce EOS Chemistry science data products as defined in this Project Plan
- communicate the purpose, benefits, and findings of the Chemistry mission to the public via effective outreach techniques such as the Chemistry Home Page <<http://eos-chem.gsfc.nasa.gov>>

2.3 PERFORMANCE INDICATORS

To verify achievement of its goals and objectives, the Chemistry Project will evaluate performance indicators in the following ways:

- adherence to a yearly development schedule and cost plan
- periodic assessment and measurement of actual performance against planned performance

3. Customer Definition and Advocacy

3.1 CUSTOMER DEFINITION

The Chemistry Project's programmatic customers are:

1. NASA Headquarters' Earth Science Enterprise, Code Y
2. EOS-G Program Office, Code 420

The Chemistry Project's mission customers are the HIRDLS, MLS, OMI, and TES Principal Investigators.

3.2 CUSTOMER ADVOCACY

The process used to ensure customer advocacy begins with acquiring and prioritizing customer requirements, and includes customer involvement in any requirements trades that become necessary during the course of the program. The customers' requirements are flowed down to the development specifications. The process continues with periodic re-verification of the requirements and verification of their implementation during development of the flight and ground systems. Verification takes place in the form of reviews, inspections, and testing. The process concludes with the pre- and post-launch validation of flight and ground systems.

4. Project Authority

The EOS Chemistry Project is managed by the Flight Projects Directorate, Code 400, GSFC. It receives its programmatic direction and resources from the EOS-G Program Office (Code 420). The Project is funded by Unique Project Number (UPN) 228 - EOS Chemistry Flight .

GSFC is the lead Center for EOS and is where the GPMC resides for the EOS Chemistry Project. JPL, which provides the MLS and TES instruments for the EOS Chemistry Mission, is a supporting Center for the mission.

The NASA Headquarters organization programmatically responsible for the EOS Program is the Operations, Programming Planning and Development Division (Code YF) in the Earth Science Enterprise (Code Y).

5. TECHNICAL SUMMARY

5.1 BACKGROUND

This section presents an overview of the EOS Chemistry Project system-level functional and performance requirements. This information is intended to serve as a context and basis for the project organization, staffing, policies, and processes which are the primary subject of this document, and not as a controlled baseline for implementation.

5.2 PROJECT CHARACTERISTICS

The EOS Program will develop a sun-synchronous space-based Earth Observing System which will provide global science data from a low altitude sun-synchronous orbit on a long-term sustained basis.

The EOS Chemistry Mission will study the chemical interactions and climate change in the Earth's atmosphere, focusing on the upper troposphere and lower stratosphere. The science instruments will measure:

- troposphere ozone and its precursors
- stratospheric ozone and trace gasses that control the production and loss of ozone
- aerosol properties of the troposphere and stratosphere
- atmospheric temperature and humidity
- total column ozone and surface ultraviolet

The deployed EOS CHEM-1 Observatory is shown in Figure 5-1.

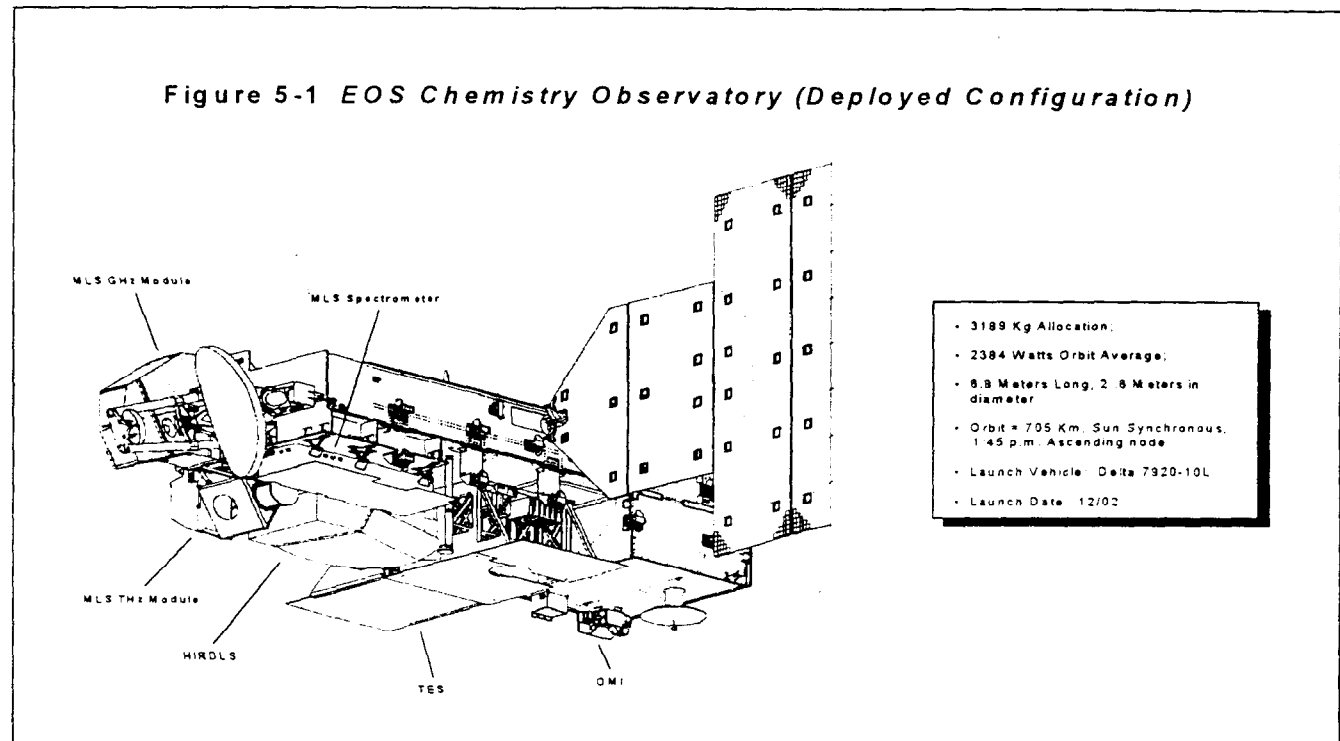
5.3 EOS CHEMISTRY PROJECT LEVEL 1 REQUIREMENTS

The Level 1 requirements for the EOS Chemistry Project are given below. These requirements serve as the baseline for derivation of lower level performance requirements.

5.3.1 General Level 1 Requirements

5.3.1.1 Management of the EOS Chemistry Mission

The EOS Chemistry Mission shall be planned and executed in conformance with NPG 7120.5A, NASA Program and Project Management Processes and Requirements. The EOS Chemistry Mission shall also be planned and executed in accordance with GPG 7120.2, Project Management.



5.3.1.2 Classification Criteria

The EOS Chemistry Mission shall be considered a Class "B" mission.

5.3.1.3 Consultative Committee on Space Data Systems Standards

The EOS Chemistry Mission shall conform to the Consultative Committee on Space Data Systems (CCSDS) recommended standards that pertain to EOS flight requirements.

5.3.1.4 Data Formats

The EOS Chemistry Observatory shall utilize standardized data formats in communications between spacecraft subsystems, instruments, and ground support equipment.

5.3.1.5 Data Transmission

The EOS Chemistry flight shall be capable of delivering not less than 95% of all payload-related data to the DAACs and to the Level 0 backup archive during each orbit repeat cycle.

5.3.1.6 Communications

The EOS Chemistry spacecraft shall be designed to communicate to ground stations for science, health, safety, and command data. The EOS CHEM spacecraft shall be able to use the Tracking and Data Relay Satellite (TDRS) System for health and safety data and for command data.

5.3.1.7 System Testing

The EOS Chemistry spacecraft in conjunction with the EOS ground system, shall provide the capability to test the functionality and performance of the end-to-end system to verify system changes and upgrades, without the interruption of operational support.

5.3.1.8 Technology Transfer

The EOS Chemistry Project shall, subject to U. S. Technology Transfer Policy, make appropriate technology available to the international partner agencies participating through the EO-ICWG in the development of the IEOS.

5.3.1.9 Orbital Debris

The EOS Chemistry spacecraft and instruments shall be designed to minimize generation of orbital debris in accordance with The NASA Policy for Limiting Orbital Debris Generation, NPD 8710.3.

5.3.1.10 EOS Data Policy

The EOS Chemistry Project shall require all EOS investigators to adhere to the EOS Data Policy (see Appendix C of the Execution Phase Project Plan for EOS) for research use by affiliated users.

5.3.1.11 Science Investigation

The EOS-G Program Office and EOS Chemistry Project shall assure the provision of a SCF to each U.S. EOS science investigation they manage.

5.3.1.12 Environmental Impact

- The EOS Chemistry Mission shall be planned and executed in conformance with NASA Regulations entitled Environmental Quality (14 CFR Part 1216).
- The EOS Chemistry Mission shall be planned and executed in conformance with other relevant Federal environmental laws, regulations, and Executive Orders.
- The EOS Chemistry Mission shall be planned and executed in conformance with other NPGs and NMIs addressing environmental issues.

5.3.2 EOS Chemistry Specific Level 1 Requirements

5.3.2.1 EOS Chemistry Mission

The EOS Chemistry spacecraft shall be designed for a six year operational lifetime. The instruments for the Chemistry Mission shall have a minimum design lifetime of 5 years. The EOS Chemistry spacecraft shall be launched in 2002. The EOS Chemistry spacecraft is being procured as the second of the EOS Common Spacecraft, the first of which is being developed for the EOS PM-1 Mission.

5.3.2.1.1 Launch of Spacecraft

The EOS CHEM spacecraft shall be designed to be launched by a medium class ELV.

5.3.2.1.2 Orbit of Spacecraft

The EOS CHEM spacecraft shall be inserted into a 16-day, 233-orbit repeat sun-synchronous orbit with 1:45 pm \pm 15 minutes ascending nodal crossing (nominally 705 km, 98.2° inclination).

5.3.2.1.3 Instrument Payload

The EOS CHEM spacecraft includes the following suite of instruments: High-Resolution Dynamics Limb Sounder (HIRDLS), Microwave Limb Sounder (MLS), Tropospheric Emission Spectrometer (TES), and Ozone Monitoring Instrument (OMI). The instrument characteristics and standard data products applicable to each investigation are defined in Section 5.4.

5.3.2.1.4 Intercomparison of Science Data

Each EOS Chemistry instrument shall be calibrated in a controlled environment prior to launch. In the post-launch period, measurements will be compared to other satellite, ground, balloon, and aircraft measurements as part of the EOS validation program.

5.3.2.1.5 Communications

The EOS CHEM spacecraft shall support the scheduled intermittent direct downlink of stored science and engineering data to ground stations. The spacecraft shall be compatible with both TDRSS and ground stations for command and control.

5.3.2.1.6 Spacecraft Health and Safety

The spacecraft shall support detection, isolation, and recovery capabilities for any single fault to ensure the health and safety of the spacecraft, (except for structure, pressure vessels). Other exceptions to the single fault recovery shall be in accordance with NMI 8010.1A.

5.3.2.1.7 Investigator Responsibilities

The EOS Chemistry PIs shall be responsible for the development and maintenance of algorithms and source code to generate the respective Standard Data Products listed in each instrument's section.

5.3.3 Instrument Level 1 Requirements

5.3.3.1 High Resolution Dynamics Limb Sounder (HIRDLS)

5.3.3.1.1 Description

The HIRDLS instrument, a Co-PI instrument, is an infrared limb-scanning radiometer. The HIRDLS science objectives are to make observations of the upper troposphere, stratosphere, and mesosphere to determine temperature; the concentrations of atmospheric species and aerosols; and the locations of polar stratospheric clouds and cloud tops.

5.3.3.1.2 Level 1 Requirements

The HIRDLS shall contribute to understanding the physical and chemical fluxes between the troposphere and stratosphere and to understanding upper tropospheric chemistry. The HIRDLS shall provide the Standard Data Products shown in Table 5-1.

5.3.3.2 Microwave Limb Sounder (MLS)

5.3.3.2.1 Description

The MLS instrument, a PI instrument, is a passive microwave radiometer/spectrometer which measures millimeter and submillimeter wavelength radiation from the atmospheric limb. The MLS science objectives are to provide crucial information on ozone depletion and radiative forcing of climate at altitudes from the upper troposphere to the mesosphere. An important feature of the MLS measurements is that they are not degraded by clouds or volcanic aerosols.

5.3.3.2.2 Level 1 Requirements

The MLS shall make measurements that are critical for understanding global change in the upper troposphere and stratosphere. These measurements shall be transformed to usable geophysical data products from which scientific information is extracted and communicated to the scientific community and policy makers. The MLS shall provide the Standard Data Products shown in Table 5-1.

5.3.3.3 Tropospheric Emission Spectrometer (TES)

5.3.3.3.1 Description

The TES instrument, a PI instrument, is a high spectral resolution infrared imaging Fourier Transform Spectrometer. The TES science objectives include the investigation of biochemical cycles of the interaction of the lower atmosphere and the biosphere, global climate modification due to greenhouse gases, acid deposition precursors, the exchange of gases between stratosphere and troposphere, and the distribution of tropospheric ozone and carbon monoxide.

5.3.3.3.2 Level 1 Requirements

TES shall contribute to the understanding of changes in tropospheric chemistry through a combination of measurements of the global distribution of tropospheric ozone and its sources and sinks. The TES shall provide the Standard Data Products shown in Table 5-1.

5.3.3.4 Ozone Monitoring Instrument (OMI)

5.3.3.4.1 Description

The OMI, a PI instrument, is a non-scanning push-broom imaging spectrometer. The OMI science objectives are to map total column densities and profiles of ozone and aerosols world-wide, using backscattered sunlight. The OMI will be contributed by the Netherlands Agency for Aerospace Programmes (NIVR). The Netherlands has an agreement with the Finnish Meteorological Institute (FMI) to provide the electronics unit for the OMI, and to contribute to the science investigation.

5.3.3.4.2 Level 1 Requirements

The OMI shall continue the measurements of global total ozone and surface ultraviolet that were established by the NASA Total Ozone Mapping System (TOMS) instrument. The OMI shall provide the Standard Data Products shown in Table 5-1.

Instrument	Product Name	Units	Accuracy Abs.:Rel	Temporal Resolution ¹	Horizontal Resol.:Cover ²	Vertical Resol.: Cover ²
HIRDLS	Level-1B Product	$W/M^2/sr$			500 km::G	
	Aerosol Extinction Coef (4 Channels)	/km	5-10%::1-10%	2/day [d,n]	500 km::G	1 km:: 5-80 km (given accuracies for 7-30 km)
	CFC-11 (CFC1 ₃) concentration	mixing ratio	5-10%::1-10%	2/day [d,n]	500 km::G	1 km:: 5-50 km (given accuracies for 7-30 km)
	CFC-12 (CF ₂ Cl ₂) concentration	mixing ratio	5-10%::1-10%	2/day [d,n]	500 km::G	1 km:: 5-55 km (given accuracies for 7-30 km)
	CH ₄ concentration	mixing ratio	5-10%::1-10%	2/day [d,n]	500 km::G	1 km:: 5-65 km (given accuracies for 7-65 km)
	ClONO ₂	mixing ratio	5-10%::3-15%	2/day [d,n]	500 km::G	1 km:: 15-65 km
	Cloud Top Properties			2/day [d,n]	500 km::G	
	Geopotential Height-Gradient	m/km	0.04m/km:: 0.04m/km	2/day [d,n]	500 km::G	1 km:: 5-80 km (given accuracies for 15-80 km)
	H ₂ O concentration	mixing ratio	5-10%::1-10%	2/day [d,n]	500 km::G	1 km:: 5-70 km (given accuracies for 7-70 km)
¹ [d,n] represents Day and Night, respectively; ² G represents Global Coverage Note: These standard data products are preliminary pending negotiation and agreement with the responsible EOS investigators.						

Table 5-1
EOS Chemistry Standard Data Products

Instrument	Product Name	Units	Accuracy Abs.:Rel	Temporal Resolution ^{1,2}	Horizontal Resol.:Cover ³	Vertical Resol.:Cover ⁴
HIRDLS	HNO ₃ concentration	mixing ratio	5-10%:1-10%	2/day [d,n]	500 km:G	1 km: 5-50 km (given accuracies for 10-40 km)
	N ₂ O concentration	mixing ratio	5-10%:1-10%	2/day [d,n]	500 km:G	1 km: 5-70 km (given accuracies for 7-60 km)
	N ₂ O ₅ concentration	mixing ratio	5-10%:1-10%	2/day [d,n]	500 km:G	1 km: 10-65 km (given accuracies for 15-45 km)
	NO ₂	mixing ratio	5-10%:3-10%	2/day [d,n]	500 km:G	1 km: 5-65 km (given accuracies for 10-55 km)
	O ₃	mixing ratio	5-10%:1-10%	2/day [d,n]	500 km:G	1 km: 5-80 km (given accuracies for 7-80 km)
	Temperature/Pressure Profile	K	<50 km 1%:0.5% >50 km 2.5%:1.5%	2/day [d,n]	500 km:G	1 km: 8-80 km
MLS	MLS Radiances	K	absolute accuracy is 2K or better; precision varies, with -0.01K achieved on long term averages	2/day [d,n]	500 km:G	0.1-1 km:0-120 km
¹ [d,n] represents Day and Night, respectively; ² The temporal resolutions for MLS are valid for both time-sharing and full-power operating modes; ³ G represents Global Coverage; ⁴ The SO ₂ maps will likely be useful only after volcanic eruptions. Note: These standard data products are preliminary pending negotiation and agreement with the responsible EOS investigators						

Table 5-1 (Cont)
EOS Chemistry Standard Data Products

Instrument	Product Name	Units	Accuracy Abs.:Rel	Temporal Resolution ¹	Horizontal Resol.:Cover ²	Vertical Resol.: Cover ³
MLS (cont)	temperature	K	1-2K::0.3-1K (5-40 km)	daily global map	500 km::G	3 km::5-120 km
	geopotential height	m	30-100 m::10-30 m (10-50 km)	daily global map	500 km::G	3 km::5-120 km
	cirrus ice content		5-10%::0.005 g/m ³	monthly global map	200 km::G	3 km::10-20 km
	H ₂ O concentration	mixing ratio	3-5%::2-10% (5-50 km)	daily global map	500 km::G	3 km::5-100 km
	N ₂ O concentration	mixing ratio	3-5%::0.02-0.05 ppmv (10-45 km)	daily global map	500 km::G	3 km::10-60 km
	CO concentration	mixing ratio	3-5%::8-20 ppbv (8-30 km)	monthly global map	500 km::G	3 km::8-100 km
	O ₃ concentration (stratosphere)	mixing ratio	3-5%::0.5-10% (15-50 km)	daily global map	500 km::G	3 km::15-100 km
	O ₃ concentration (troposphere)	mixing ratio	3-5%::2-10 ppbv (8-15 km)	monthly global map	500 km::G	3 km::8-15 km
	OH concentration (lower stratosphere)	mixing ratio	3-10%::0.2-0.5 pptv (18-35 km)	monthly zonal mean	500 km::G	3 km::18-30 km
	OH concentration (upper stratosphere)	mixing ratio	3-10%::10% (35-60 km)	daily global map	500 km::G	3 km::30-80 km
¹ The temporal resolutions for MLS are valid for both time-sharing and full-power operating modes; ² G represents Global Coverage; ³ The SO ₂ maps will likely be useful only after volcanic eruptions. Note: These standard data products are preliminary pending negotiation and agreement with the responsible EOS investigators						

Table 5-1 (Cont)
EOS Chemistry Standard Data Products

Instrument	Product Name	Units	Accuracy Abs.:Rel	Temporal Resolution ¹	Horizontal Resol.:Cover ²	Vertical Resol.: Cover ³
MLS (cont)	HO ₂ concentration	mixing ratio	3-10%:5-50 pptv (20-50 km)	monthly zonal mean	500 km::G	3 km::20-60 km
	BrO concentration	mixing ratio	3-10%:3-6 pptv (20-40 km)	monthly zonal mean	500 km::G	5 km::20-40 km
	ClO concentration	mixing ratio	3-5%:0.1-0.5 ppbv (15-45 km)	daily global map	500 km::G	3 km::15-60 km
	HCl concentration	mixing ratio	3-5%:0.06-1 ppbv (10-55 km)	daily global map	500 km::G	3 km::12-100 km
	HOCl concentration	mixing ratio	3-10%:0.01-0.1 ppbv (20-50 km)	monthly zonal mean	500 km::G	3 km::20-50 km
	HNO ₃ concentration	mixing ratio	3-5%:2-5 ppbv (10-30 km)	daily global map	500 km::G	3 km::10-60 km
	HCN concentration	mixing ratio	3-10%:0.05-0.2 ppbv (8-40 km)	daily zonal mean	500 km::G	5 km::8-50 km
	SO ₂ concentration	mixing ratio	3-10%:2 ppbv	daily global map	500 km::G	3 km::10-40 km
TES	Level-1B Radiance, TES [IR spectra in selected bands 3.2-15.4 μ m]	W/m ² /sr/ μ m	1%:1%	1/(4 day)	5.3 x 8.5 km::G	
¹ The temporal resolutions for MLS are valid for both time-sharing and full-power operating modes; ² G represents Global Coverage; ³ The SO ₂ maps will likely be useful only after volcanic eruptions. Note: These standard data products are preliminary pending negotiation and agreement with the responsible EOS investigators						

Table 5-1 (Cont)
EOS Chemistry Standard Data Products

CHECK THE GSFC DIRECTIVES MANAGEMENT SYSTEM AT
<http://gdms.gsfc.nasa.gov/gdms> TO VERIFY THAT THIS IS THE CORRECT VERSION PRIOR TO USE.

Instrument	Product Name	Units	Accuracy Abs::Rel	Temporal Resolution	Horizontal Resol::Cover ¹	Vertical Resol::Cover
TES (cont)	CH ₄ mixing ratio	ppbv	3%::14 ppbv	1/(4 day)	5.3 x 8.5 km::G	2-6 km::0-34 km
	CO mixing ratio	ppbv	3%::10 ppbv	1/(4 day)	5.3 x 8.5 km::G	2-6 km::0-34 km
	HNO ₃ mixing ratio	pptv	5%::3 pptv	1/(4 day)	5.3 x 8.5 km::G	2-3 km::0-34 km
	NO mixing ratio	pptv	15-25 pptv	1/(4 day)	53 x 169 km::G	2-3 km::5-34 km
	NO ₂ mixing ratio	pptv	5%::500 pptv	1/(4 day)	53 x 169 km::G	2-3 km::5-34 km
	O ₃ mixing ratio	ppbv	3%::3-20 ppbv	1/(4 day)	53 x 169 km::G	2-6 km::0-34 km
	Temperature Profile	K	2 K::0.2 K	1/(4 day)	53 x 169 km::G	4-6 km::0-34 km
	H ₂ O/HDO mixing ratio	ppmv	3%::0.5-50 ppmv	1/(4 day)	53 x 169 km::G	2-6 km::0-34 km
	Land sfc Brightness Temperature	K	1 K:: 0.1 K	1/(4 day)	53 x 169 km::G	NA::sfc
	Level 2 detection flags	none			53 x 169 km::G	
OMI	Solar Irradiance	W/cm ²	3%::<1%	1 view/orbit	NA	NA
	Radiances	W/cm ² /sr	3%::1%	1 view/2 sec	13 x 24 km::G Daylight	NA
¹ G represents Global Coverage Note: These standard data products are preliminary pending negotiation and agreement with the responsible EOS investigators						

Table 5-1 (Cont)
EOS Chemistry Standard Data Products

Instrument	Product Name	Units	Accuracy Abs::Rel	Temporal Resolution	Horizontal Resol::Cover ¹	Vertical Resol::Cover
OMI (cont)	Total Ozone	milli-atm-cm	3%::1%	1 view/2 sec	13 x 24 km::G Daylight	Column
	Ozone Profile	ppmv	10%::5%	1 view/4 sec	13 x 48 km::G Daylight	8 km::25-50 km 10 km::0-25 km
	Aerosol Index	Unitless (1-10)	NA	1 view/2 sec	13 x 24 km::G Daylight	Column
	UVB	W/cm ²	10%::2%	1 view/2 sec	13 x 24 km::G Daylight	surface
	Aerosol Optical Thickness	cm	0.1::0.05 (weak absorbers) 30%::10%	1 view/2 sec	13 x 24 km::G Daylight	Column
	Cloud Heights	mbar	100mb::30mb	1 view/2 sec	13 x 24 km::G Daylight	surface
	SO ₂	mol/cm ²	20%::1 x 10 ⁻¹⁶ mols/cm ²	1 view/4 sec	13 x 24 km::G Daylight	Column
	NO ₂	mol/cm ²	TBD	TBD	TBD	Column
	BrO	mol/cm ²	TBD	TBD	TBD	Column
	OCIO	mol/cm ²	TBD	TBD	TBD	Column
¹ G represents Global Coverage Note: These standard data products are preliminary pending negotiation and agreement with the responsible EOS investigators						

Table 5-1 (Cont)
EOS Chemistry Standard Data Products

5.3.4 Observatory System Integration and Test

For the Chemistry Project spacecraft, an observatory level integrated spacecraft and instruments test program will be conducted to demonstrate that the observatory can withstand and perform properly when subjected to the expected launch and orbit environments. This test program will include an end-to-end system test, which will simulate orbital performance and verify compatibility of the total flight and ground segments.

6. MANAGEMENT

6.1 EOS CHEMISTRY PROJECT MANAGEMENT RESPONSIBILITIES AND ORGANIZATION

Management responsibilities and procedures for the EOS Chemistry Project are established in accordance with NASA Program and Project Management Processes and Requirements, NPG 7120.5A, dated April 3, 1998, and with GSFC's Project Management, GPG 7120.2. The EOS Chemistry Project Staff interfaces with functional GSFC directorates and facilities to plan, implement, and coordinate development of the Chemistry Spacecraft. The Project organization chart is shown in Figure 6-1.

6.1.1 EOS Chemistry Project Manager

The EOS Chemistry Project organization shown in Figure 6-1 is headed by the Project Manager, the senior official at GSFC exclusively responsible for managing execution of the project life-cycle. The EOS Chemistry Project Manager has full authority to carry out this responsibility within guidelines assigned by the Associate Director of Flight Projects for EOS-G.

Specific responsibilities include directing and overseeing:

- Preparation and maintenance of project plans, specifications, schedules, and budgets
- Acquisition and utilization of participating contractors
- Execution of project plans by government, contractor, and university participants in conformance with all project commitments and constraints and with all agency policies
- Performing project level SE&I
- Reporting project status and contractor performance as required
- Establishing and maintaining a close and effective working relationship with the Program Manager

The EOS Chemistry Project Manager discharges the responsibilities with the assistance and support of individuals and organizations assigned either administratively or functionally to the EOS Chemistry

Project. The EOS Chemistry Project Manager is responsible for the development of the spacecraft and instruments included in the WBS elements under UPN 228.

6.1.2 EOS Chemistry Deputy Project Manager (DPM)

The EOS Chemistry Deputy Project Manager is responsible to the EOS Chemistry Project Manager and is an integral member of the management team for the Chemistry Project. The EOS Chemistry DPM supports the EOS Chemistry Project Manager in directing all phases of the EOS Chemistry Project and has Project-wide responsibility for personnel management and planning and evaluating all EOS Chemistry Project activities on a day-to-day basis. The DPM provides technical management to the team of technically skilled specialists and their supporting personnel in order to meet performance, cost, and schedule commitments. In the absence of the Project Manager, the DPM assumes full responsibility for the Project.

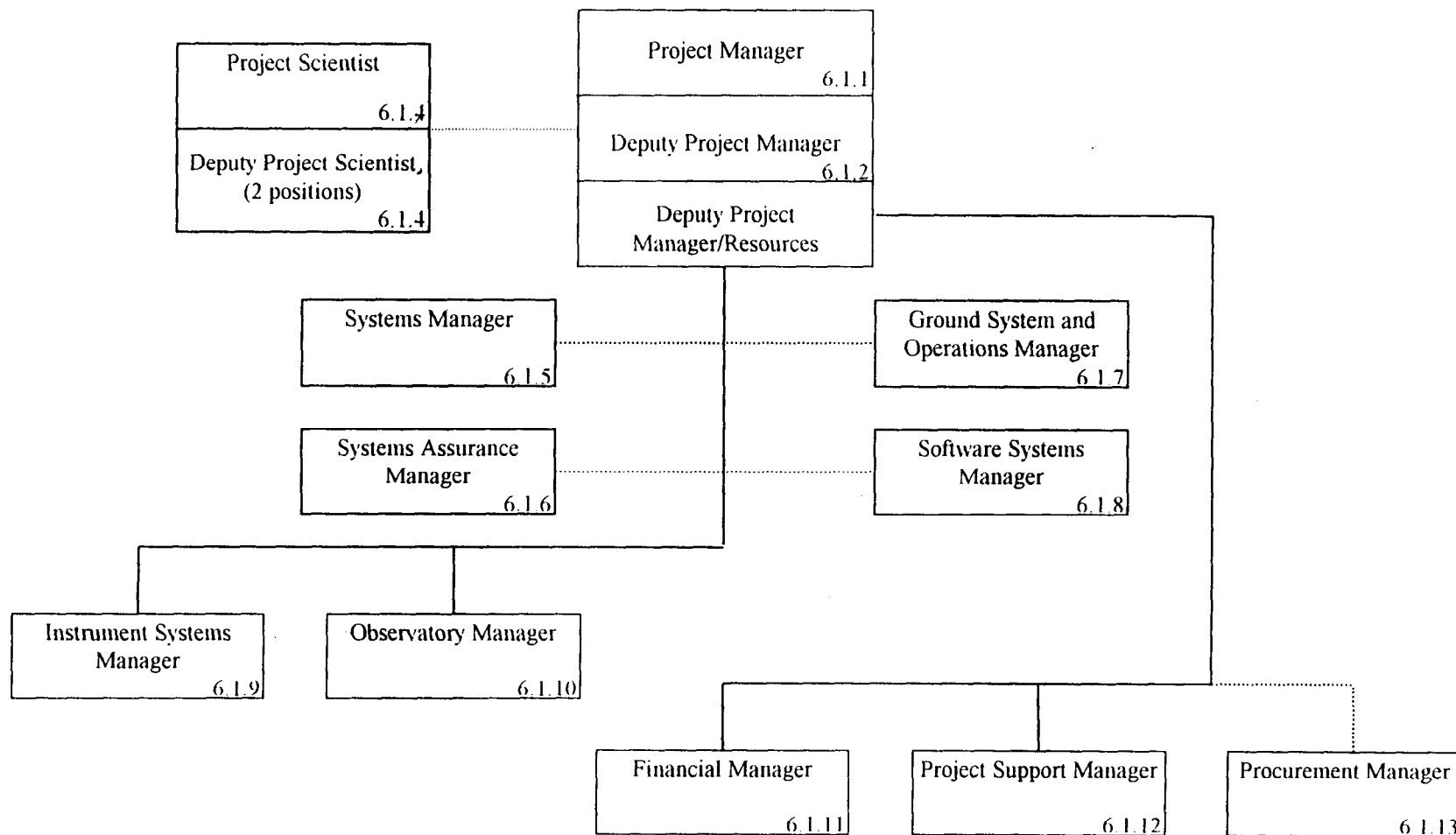
6.1.3 Deputy Project Manager/Resources (DPM/R)

The EOS Chemistry Deputy Project Manager/Resources is responsible to the EOS Chemistry Project Manager and is an integral member of the management team for the EOS Chemistry Project. The EOS Chemistry DPM/R contributes business management expertise to the establishment of technical program objectives and is responsible for the application of business, financial management, and performance measurement techniques to the accomplishment of those objectives. The EOS Chemistry DPM/R supervises a team of specialists in the areas of finance, budget, performance measurement, scheduling, pricing, configuration management, etc., and is responsible for the application of sound business techniques to the accomplishment of EOS Chemistry Project objectives. In addition, the EOS Chemistry DPM/R provides requirements to the EOS Chemistry Project Procurement Manager on Project-related matters. In the absence of the EOS Chemistry Project Manager and the EOS Chemistry DPM, the EOS Chemistry DPM/R may act for the EOS Chemistry Project Manager.

6.1.4 Project Scientists (910)

The EOS Chemistry Project Scientists, from the Earth Sciences Directorate at GSFC, are responsible for ensuring the satisfactory accomplishment of the scientific objectives of EOS Chemistry missions and are integral members of the management team for the EOS Chemistry Project. The EOS Chemistry Project Scientists review the planning and implementation of the EOS Chemistry Project to ensure that the total mission is consistent with the overall scientific objectives. The EOS Chemistry Project Scientists provide leadership in ensuring that the scientific data are used effectively and the scientific results of the mission are produced expeditiously. The Project Scientists provide appropriate inputs to the PDMP's. The EOS Chemistry Project Scientists evaluate all scientific requirements placed on the EOS Chemistry Project, provide scientific guidance to the EOS Chemistry Project Manager, and provide information and recommendations to the EOS Senior Project Scientist and others involved in the Program. The EOS Chemistry Project Scientists' authority includes serving as the primary Project liaison to the Instrument Science Teams, and making recommendations to the EOS Senior Project Scientist on science funding levels appropriate for calibration, product validation

Figure 6-1 Chemistry Project Organization Chart



and algorithm development for appropriate Science Teams. The EOS Chemistry Project Scientists and the Program Scientist communicate and coordinate on science issues.

6.1.5 Systems Manager (730)

The EOS Chemistry Project Systems Manager is responsible to the EOS Chemistry Project Manager for all systems aspects of the flight and ground segment systems. The incumbent is responsible for developing the systems design of the spacecraft/observatory system, and for ensuring that it is compatible with the scientific instruments, launch vehicle, ground system, and reliability objectives. The incumbent establishes interface constraints and requirements for subsystems; resolves interface and system level performance questions and problems; reviews and approves for manufacture, the electrical flight hardware designs; and oversees the electrical integration and test of the Chemistry spacecraft. The incumbent reviews performance data and measurements throughout the Project to ensure that flight and ground systems meet stated requirements and objectives. Specifically, the Chemistry Systems Manager has review and signoff responsibilities for all major system-level functional performance and design specifications; performs risk assessments, and evaluates design margins and inadequacies; reviews all major test plans and procedures, compares predicted and actual performance of systems; and reports routinely to the Chemistry Project Manager on the status of system engineering activities. The incumbent serves as chairman for major failure-review committees, and advises the Director of Flight Projects as to major (critical) aspects of these assignments.

6.1.6 Systems Assurance Manager (303)

The EOS Chemistry Project Systems Assurance Manager, from the Office of Flight Assurance, is responsible to the EOS Chemistry Project Manager for all flight assurance disciplines of the Chemistry Project to ensure that the spacecraft, instruments, and ground system equipment (hardware and software) will meet their intended performance objectives. These disciplines include quality assurance, design review, reliability, system safety, parts, materials, processes, contamination control, and verification testing. The incumbent is responsible for the coordination of GSFC Systems Assurance Resident personnel or other Government Inspection Agency (GIA) personnel.

6.1.7 Ground System and Operations Manager (423)

The Ground System and Operations Manager (GSOM) is responsible for coordinating the development of the EOS ground system and operations needed to support the Chemistry mission. The GSOM works closely with the ground system development teams and ensures that the requirements for the Chemistry mission are well understood and implemented in the ground system. The GSOM is also responsible for the overall operations of the spacecraft and instruments; he/she works with the instrument teams and spacecraft contractor to determine operations requirements and to generate an integrated mission operations concept and mission operations plan.

6.1.8 Software Systems Manager (582)

The Software Systems Manager is responsible to the Project Manager for the successful management of the Project's acquisition of software that meets requirements and is delivered on schedule and within

budget. These responsibilities include but are not limited to, serving as the focal point for all matters pertaining to the acquisition of software; developing and maintaining the Project's Software Management Plan; determining whether a software life cycle phase has been completed and the next phase may be started; ensuring that software providers use processes appropriate to the criticality of the software under development; and participating in interface working groups.

6.1.9 Instrument Systems Manager (ISM)

The EOS Chemistry ISM is responsible to the EOS Chemistry Project Manager for close liaison and monitoring of instrument development performed by GSFC organizations or by outside institutions, such as universities or contractors, and for evaluation of instrument performance after launch. The EOS Chemistry ISM must ensure, through coordination and technical review of designs, that the instruments meet the technical performance, cost, and schedule parameters for the basic EOS Chemistry mission requirements. The EOS Chemistry ISM is responsible for coordinating the spacecraft bus/instrument interfaces and for ensuring that the related ground support equipment is provided. The EOS Chemistry ISM has overall responsibility for managing and directing the contracts and agreements for instrument development and science. The EOS Chemistry ISM provides a single point of contact to the EOS Chemistry Project instrument developers and scientists for all NASA functions, including science funding.

6.1.10 Observatory Manager

The EOS Chemistry Project Observatory Manager is responsible to the EOS Chemistry Project Manager and coordinates and directs the efforts of a team of government and industry specialists: to identify and specify the mission-imposed observatory requirements; to develop subsystems and systems to meet those requirements fully; and to demonstrate that the CHEM observatory, the "Common Spacecraft," and its components meet their functional and performance goals in the launch and space environments. The incumbent ensures that the facilities, tools, fixtures, test equipment, and automated data processing hardware and software required in fabricating, integrating, and testing the subsystems and of the "Common Spacecraft," are procured or developed and available at the appropriate times and places to support the launch of the Chemistry mission. The Chemistry Project Observatory Manager is responsible for planning and managing these tasks so that they will be completed on schedule and within the available resources.

6.1.11 Financial Manager

The EOS Chemistry Project Financial Manager is a member of the business support team and reports to the EOS Chemistry DPM/R. The EOS Chemistry Project Financial Manager is responsible for the application of sound financial management principles in the areas of cost control, performance measurements, financial analysis, budget preparation and execution, and pricing.

6.1.12 Project Support Manager

The EOS Chemistry Project Support Manager, is a member of the business support team reporting to the EOS Chemistry DPM/R. The EOS Chemistry Project Support Manager is responsible for

scheduling, configuration management, logistics management, workforce analysis, property management and control, and other general administration and overall EOS Chemistry Project planning activities.

6.1.13 Procurement Manager (214.3)

The EOS Chemistry Project Procurement Manager, from the Management Operations Directorate, is responsible for all procurement functions of the EOS Chemistry Project including planning, directing, coordinating, and evaluating all EOS Chemistry Project procurement activities in accordance with NASA authoritative guidelines and coordinating these activities with the EOS Chemistry DPM/R.

6.2 MANAGEMENT SUPPORT SYSTEMS

6.2.1 Project Monthly Status Review

The Chemistry Project holds monthly reviews of the Project's progress. See section 19.2.2 for more details on the MSR.

6.2.2 Monthly Coordination Review (MCR)

The Chemistry Project provides a monthly overview of Project status to the Flight Projects Directorate in the MCR.

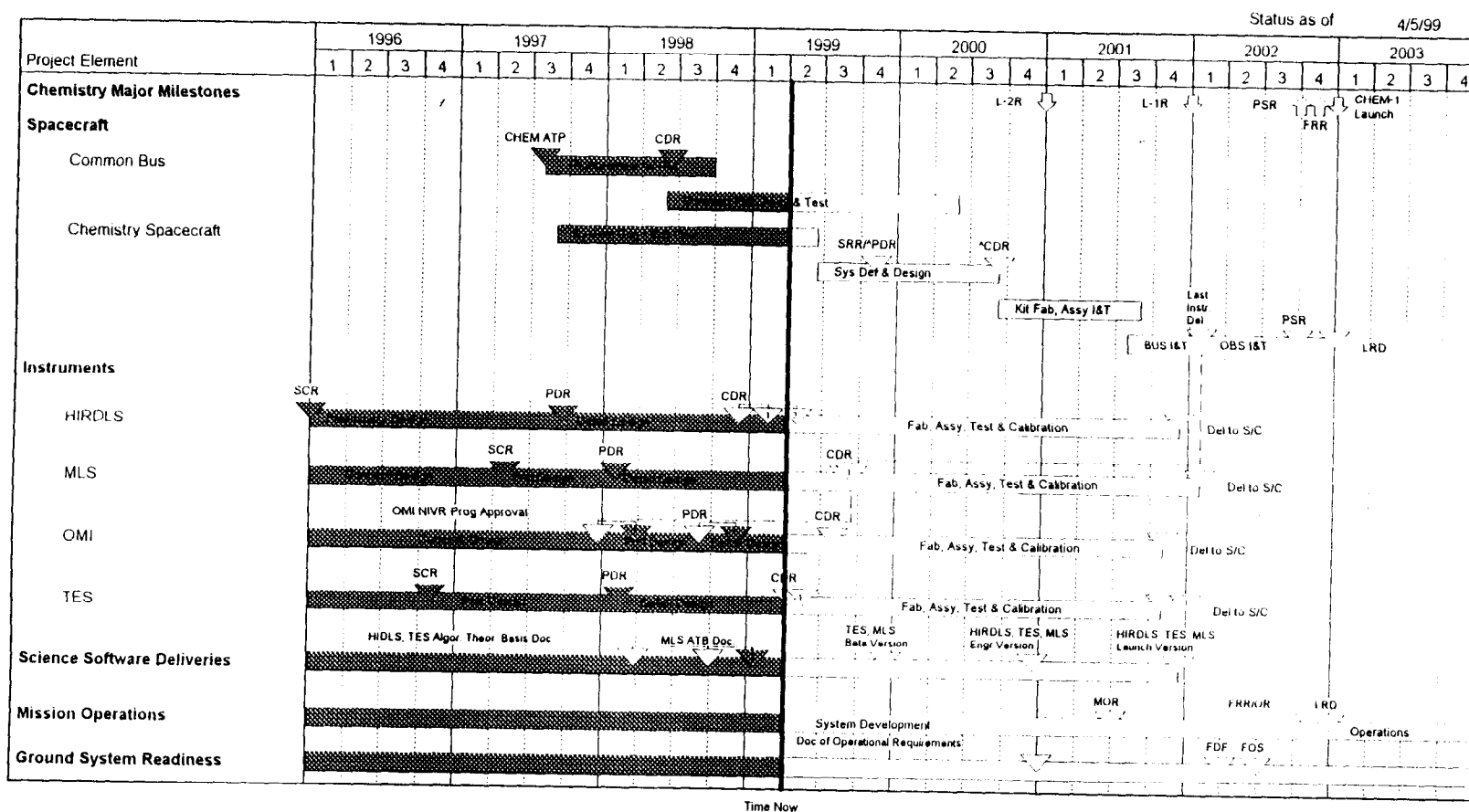
6.2.3 Monthly Status Review (MSR)

The Chemistry Project provides a monthly overview of Project status to the GSFC Program Management Council (GPMC) in the MSR.

7. SCHEDULES

The Chemistry Project Schedules are maintained by the Project and reported monthly to management in the regular review process. The schedules must include all Level 1 controlled milestones identified in the PCA. The Level 1 milestone is CHEM-1 LRD 12/02. An unofficial (i.e., "working") version of the EOS Chemistry Project Master Schedule is shown below.

EOS Chemistry Project Code 424 Master Schedule



EOS Chemistry Project Master Schedule

CHECK THE GSFC DIRECTIVES MANAGEMENT SYSTEM AT
<http://gdms.gsfc.nasa.gov/gdms> TO VERIFY THAT THIS IS THE CORRECT VERSION PRIOR TO USE.

8. RESOURCES

8.1 FUNDING REQUIREMENTS

Funding requirements for the EOS Chemistry Project are reflected in the current Program Operating Plan.

8.2 INSTITUTIONAL REQUIREMENTS

The Civil Service workforce requirements for the EOS Chemistry Project are contained in the Center workforce database and are updated annually as a result of the workforce call.

9. CONTROLS

9.1 CHANGE/CONFIGURATION MANAGEMENT

All technical performance, cost, or schedule changes not impacting the EOS-G Program Commitment Agreement are under the control of the Chemistry Project Manager and will be handled in accordance with the 400-PG-8700.2.1, Configuration Control Document.

The Chemistry Project Manager will chair the Configuration Control Board (CCB), with representation on the CCB by all major project elements, including science, spacecraft, instrument, and ground system. The CCB is responsible for all changes affecting mission objectives, program cost, scheduled launch date, mission component interfaces, and MOU requirements.

All proposed changes are designated as Class 1 or Class 2 changes. A Class 1 change is a proposed change that impacts the form, fit, function, interfaces, weight/power/data rate allocations, technical risk, science performance, cost, or schedule of a baseline configured item. Class 1 changes must be submitted for CCB approval and require the signatures of the Project Manager/CCB Chair.

A Class 2 change is limited to substitution of equivalent parts, clarifications, or clerical errors. Class 2 changes are also approved by the CCB Chair.

All changes impacting EOS-G program objectives are reviewed and controlled in accordance with the EOS-G CM Plan as described in the EOS-G Program Plan.

9.2 KEY PROGRAM PARAMETERS

The key program parameters which are used to control the program are cost and schedule. The Project holds monthly status reviews where the cost and schedule for each element is reviewed against the baseline.

9.2.1 Cost Control

Any element with a variance of more than 5% in cost will be subject to a more intensive evaluation by the Project Manager. If the projected cost growth will have any impact on the Project's cost guidelines, the EOS Program Office will be notified.

9.2.2 Schedule Control

Schedule performance will be evaluated against the critical path and elements which have the potential to impact the critical path will also be subject to a more intensive evaluation by the Project Manager. The element will be required to develop a schedule recovery plan which details how the schedule delay will be managed. If the project schedule slip will have any impact on Level 1 schedules, the EOS Program Office will be notified.

9.3 VERIFICATION OF REQUIREMENTS - CERTIFICATION

The System Assurance Manager (SAM) prepares the QA Plans and Procedures and submits them to the Chemistry Project Manager for approval. The SAM then assures compliance to the requirements and verifies that the acceptance test complies to the test plan. The SAM also validates the delivery of the hardware and software.

10. Implementation Approach

10.1 IMPLEMENTATION APPROACH

The implementation approach for each major element of the EOS Chemistry Project is described in the following sections. The approach conforms to the UPN structure identified in Section x.y and the WBS described in Section 10.2.

10.1.1 Spacecraft

The EOS Common Spacecraft is being developed and provided under a competitive CPAF contract. The basic contract is for two spacecraft, the first one for the PM mission and the second one for Chemistry, plus options for two additional spacecraft. This contract has a separate System Requirements Review for each spacecraft to verify technical requirements, including instrument accommodations. The implementation phase will include payload accommodation studies, development of interfaces, detailed design, development, fabrication, integration and test of the respective EOS spacecraft, launch support, on-orbit checkout, and 90 days of post-launch operations. The EOS CHEM flight will be launched on a medium class ELV from the Western Test Range (WTR) at VAFB.

10.1.2 Instruments

The US-funded EOS Chemistry instruments HIRDLS, MLS and TES are all PI-class instruments that were

selected for the Earth Observing System in February 1989, in response to an Announcement of Opportunity (AO) issued in January 1988. The Netherlands Agency for Aerospace Programmes agreed in April 1998 to provide the OMI (also a PI-instrument) for flight on EOS CHEM as an International contribution. A Letter of agreement between the US and UK for HIRDLS, and an Interim Letter of Agreement between the US and the Netherlands for OMI are in place. The Working Agreements with JPL for MLS and TES, and the contract with UC/Boulder and Work Share Agreement are in place. These cover instrument hardware development, fabrication, integration and test, and spacecraft integration support. Flight instruments will be delivered to the spacecraft for integration by the spacecraft provider.

Section 11 details the procurement strategy for the EOS Chemistry Project instruments.

10.2 PROJECT SUMMARY WORK BREAKDOWN STRUCTURE (WBS)

The Chemistry Project Summary WBS is shown in Figure 10-1.

EOS Chemistry Project UPN 228	
11-10	CHEM Project Support Summary
11-11	MPS/ROS
11-12	FPD Engineering Support
11-13	Performance Assurance Support
11-14	Resources Management Support
11-15	GSFC In-House Engineering Support
11-16	Thru 17 Reserved
11-18	Project Office Support
11-19	Operations Capability Development
12-20	CHEM Instrument Development
12-21	HIRDLS
12-22	SAGE III*
12-23	ACRIM*
12-24	MLS
12-25	SOLSTICE*
12-26	TES
12-27	ODUS**
12-28	OMI
12-29	Reserved
13-10	CHEM Spacecraft
13-11	Spacecraft Support
13-12	Spacecraft GFE
13-13	Thru 19 Reserved
14-10	Reserved
15-10	Reserved
16-10	Reserved
17-10	Reserved
18-10	Reserved
19-10	CHEM Contingency

*FY95 and Out - SAGE III is now 227-40-41, ACRIM is now 227-22-31, SOLSTICE is now 227-92-48

** Deleted from CHEM Instrument Complement

Figure 10-1 Chemistry Project Summary Work Breakdown Structure

CHECK THE GSFC DIRECTIVES MANAGEMENT SYSTEM AT
<http://gdms.gsfc.nasa.gov/gdms> TO VERIFY THAT THIS IS THE CORRECT VERSION PRIOR TO USE.

11. Acquisition SUMMARY

A summary of the major EOS Chemistry Project procurements is shown in Table 11-1. The procurements consist of the spacecraft, instruments, and science agreements applicable to the Chemistry Project.

Contractor	Contract Number	Contract Type	Type of Procurement	Description of Work
TRW	NAS5-32954	CPAF	Competitive	Two Common Spacecraft (one for PM, one for CHEM) and Payload Integration and Test
RAL/Oxford Univ. Matra Marconi Univ. of Colorado/LMMS-ATC	N/A NAS5-97046	International Agreement/ CPFF	Competitive	HIRDLS/Barnett, Gille; one engineering model, one flight unit, science algorithms, software delivery to ESDIS
JPL	NAS7-1407	Suballotment/ Working Agreement	Competitive	MLS/Waters: one engineering model, one flight unit, science algorithms, software delivery to ESDIS
NIVR/Fokker/ Finland	N/A	International Agreement	AO Selection	OMI: one flight unit, science algorithms, software delivery to ESDIS
JPL	NAS7-1407	Suballotment/ Working Agreement	Competitive	TES/Beer: one engineering model, one flight unit, science algorithms, software delivery to ESDIS
Boeing	Not yet under contract	N/A		Delta 7920: launch vehicle and launch vehicle operations
Raytheon/Loral		CPAF*	Competitive	EOSDIS: flight operations segment; flight operations team; Science Data Processing System

*Funded by the ESDIS Project

Table 11-1, Summary of Direct Contract Support to the Chemistry Project

12. Program/Project Dependencies

The EOS Program consists of four primary components:

1. The EOS Scientific Program
2. The EOS Algorithm Activities
3. The Earth Observation System Data and Information System (EOSDIS)
4. The EOS Flight Program

Each component has extensive interrelationships with the other three in addition to strong linkages to the Earth science community.

12.1 EOS SCIENTIFIC PROGRAM

The EOS Scientific Program focuses on defining the state of the Earth system, understanding its basic processes, and developing and applying predictive models of those processes. The science component of EOS consists of both focused-disciplinary research centered around a specific Earth science data set and interdisciplinary research geared toward a broader probe into Earth science systemic functions.

12.2 EOS ALGORITHM ACTIVITIES

The EOS Algorithm activities consist of the development, maintenance and operation of the algorithms which produce the EOS standard data products including routine intellectual quality control of these products. As such, these activities serve to unite the flight instruments, science, and the information system.

12.3 EOSDIS

The EOSDIS provides computing and network facilities to support the EOS research activities, including data interpretation and modeling; processing, distribution, and archiving of EOS data; and command and control of the spacecraft and instruments. Through the Version 0 (prototype) system and subsequent activities, the EOSDIS will also provide access to current and upcoming Earth science data sets. The EOSDIS is eventually expected to serve as the NASA ESE data system. The EOSDIS will be developed in an evolutionary manner, with extensive input from and testing by the research community. It will be on-line and tested before the launch of the first EOS spacecraft. After the first launch, the system will continue to evolve in response to the scientific research needs.

12.4 EOS FLIGHT PROGRAM

The EOS spacecraft, designated morning (AM), afternoon (PM), ICE Satellite (ICESat), and Chemistry (CHEM), will carry payloads designed to measure physical phenomena from which specific data products can be derived. The physical phenomena to be measured by each spacecraft are as follows:

- The EOS-AM spacecraft will be placed in a Sun-synchronous polar orbit with a morning Equatorial descending crossing time (hence the "AM" designation). It will fly a payload complement designed to measure physical phenomena associated with clouds, aerosols, and radiative balance. In addition, the EOS-AM will be capable of providing characterization of the terrestrial surface and ocean productivity.
- The EOS-PM spacecraft will be placed in a Sun-synchronous polar orbit with an afternoon Equatorial ascending crossing time. It will fly a payload complement designed to measure physical phenomena associated with atmospheric temperature and humidity, clouds, precipitation, radiative balance, terrestrial snow and sea ice, sea-surface temperature and ocean productivity, soil moisture, and improvement of numerical weather prediction.

- The ICESat spacecraft will perform altimetry measurements focused on evaluating ice sheet mass.
- The EOS-CHEM spacecraft will perform measurements focused on studying ozone and climate change by evaluating atmospheric chemical species and their transformations.

In addition to these EOS spacecraft, there will be EOS-funded Flight Of Opportunity (FOO) instruments that will be flown on other U.S. and international spacecraft.

12.5 EOS PROGRAM INTEGRATION

The accomplishment of the EOS Program mission objectives requires a comprehensive integration of the four Program components: Science, EOSDIS, Algorithm Development, and Flight Programs to ensure that the EOS requirements are satisfied in the broader context of NASA's ESE and the U. S. Global Change Research Program (USGCRP). For detailed information on how this integration is managed, the reader is referred to the Execution Phase Project Plan for Earth Observing System (EOS).

13. Agreements

Table 13-1 lists the Chemistry Project's approved and pending agreements.

Table 13-1, Chemistry Agreements - Approved

PARTNER	TYPE OF ACTIVITY (Flight, Ground- based/airborne, Data System, Other)	ACTIVITY	TIME PERIOD OF ACTIVITY	DATE AGREEMENT COMPLETED
UK, National Environmental Research Council (NERC)	Flight Instrument	High Resolution Dynamics Limb Sounder (HIRDLS) Development	Underway	1/6/97
UK, Rutherford Appleton Laboratory (RAL)	Flight Instrument	High Resolution Dynamics Limb Sounder (HIRDLS) Development	Underway	1/6/97
UK, Reading University	Flight Instrument	High Resolution Dynamics Limb Sounder (HIRDLS) Development	Underway	1/6/97
University of Colorado at Boulder (CU)	Flight Instrument	High Resolution Dynamics Limb Sounder (HIRDLS) Development	Underway	1/6/97
Jet Propulsion Laboratory (JPL)	Flight Instrument	Microwave Limb Sounder (MLS) Development	Underway	4/30/98
Jet Propulsion Laboratory (JPL)	Flight Instrument	Tropospheric Emission Spectrometer (TES)	Underway	4/30/98
Netherlands, The Netherlands Agency for Aerospace Programmes (NIVR)	Flight Instrument	Ozone Monitoring Instrument (OMI)	Underway	*

*Draft Memorandum of Understanding (MOU) approval pending

14. SYSTEMS ASSURANCE

14.1 GENERAL

The Chemistry Project will follow the GSFC Quality Management System for the development of products and delivery of services.

The Performance Assurance Program for the Chemistry Project is based upon the policy and requirements contained in 300-PG-7120.2.2, Mission Assurance Guidelines for Tailoring to the Needs of GSFC Projects.

The Chemistry Project's Performance Assurance Program addresses hardware and software for flight systems.

The basic elements of the Performance Assurance Program have been translated into requirements that are implemented by each instrument, each spacecraft, and the ground system and are contained in the applicable Performance Assurance Requirements (PAR) and Mission Assurance Requirements (MAR) documents for the spacecraft and instruments.

14.2 QUALITY ASSURANCE

The Quality Assurance Program requirements for the Chemistry Project follow the quality tasks delineated in the EOS MAR and PAR document series.

Activities include QA audits of products and processes, non-conformance reporting and corrective action, configuration management support, risk management support, management review support, and system safety.

14.3 PERFORMANCE VERIFICATION

14.3.1 Test and Analysis Program

A formal EOS test and analysis program shall be conducted to provide assurance that the hardware and software are capable of surviving and performing their mission within specifications under the various environments to which they will be subjected.

For the Chemistry Mission, the verification activity shall include verification requirements for the hardware and validation of the software (walkthroughs and inspections, as well as tests), as defined in the MAR and PAR documents.

14.3.2 End-to-End Compatibility Tests and Simulations

End-to-End tests will be conducted on the entire EOS Chemistry Mission and shall include all portions of the operational system, such as all flight hardware, with appropriate stimulation of instruments; operational software and ground systems, including EOSDIS internal networks, EOSDIS external networks, and ground processing facilities. These tests demonstrate that the system meets the functional requirements, and that data flow paths and actual data, in an acceptable form, are verified as required for the mission. Also, mission simulation exercises shall be conducted to validate nominal and contingency mission-operating procedures and to provide for operator familiarization training.

15. RISK MANAGEMENT PLAN

15.1 RISK PROCESS

A detailed Continuous Risk Management (CRM) Plan has been developed and documented for the EOS Chemistry Project as GSFC 424-PG-001. This CRM process closely follows the guidelines of NPG 7120.5A, NASA Program and Project Management Processes and Requirements Document, dated April 3, 1998. The basic functional steps for the project's CRM process are as follows:

- Identify - Identify risk issues and concerns
- Analyze - Evaluate (impact/severity, probability, time frame)
- Plan - Decide what, if anything, should be done about risks
- Track - Monitor risk metrics and verify/validate mitigation actions
- Control - Decide to replan mitigation's or close risks

Note: Communications and documentation are utilized throughout all the functions

15.2 CONTINUOUS RISK MANAGEMENT (CRM) PLAN

The CRM Plan compliments the overall EOS Chemistry Project Management and, therefore, CRM is an integral part of project management. CRM applies to NASA GSFC activities as well as contractors supporting the EOS Chemistry Project, including the spacecraft, instruments, and all disciplines supporting the project. The CRM Plan will support the project in the completion phase of the project development, through launch and into operational support. The project forecasts and manages risks before they become problems. To the extent possible, EOS Chemistry will utilize lessons learned from other EOS projects in carrying out the CRM Plan. The CRM Plan will be kept current by being reviewed at least annually and updated as required.

15.3 CRM IDENTIFICATION

Risks are derived from any area involving the EOS Chemistry Project. Risks may be technical or programmatic. Examples of technical risk areas include:

- Inconsistent or incomplete requirements
- Design oversights
- Unproven technologies
- Interface or integration difficulties
- Unanticipated fault detection
- Unforeseen quality and/or safety issue
- Insufficient computer capability

These and other technical risks may be with the common spacecraft or any one of four instruments. The technical risks may involve technical disciplines i.e., systems engineering, hardware and/or software engineering, integration & test, or other discipline.

Programmatic risks include all risks that are not technical by nature. However, technical risks may include some attribute of a programmatic risk like impact to cost and/or schedule. Primarily programmatic risks involve management resources, communications, and decisions.

15.4 CRM RISK TOOLS

EOS Chemistry CRM risk tools that are defined in the CRM Plan and provide support include:

- Risk Information Sheet - Identifies and provides risk tracking
- Risk Action Item List - Provides progress status and review
- EOS Chemistry WEB Site - Provides communication for CRM
- Formal/Informal Meetings - CRM as topic on agendas for status

For further information about the EOS Chemistry Project CRM, refer to the EOS Chemistry Plan and/or the Risk Action Item List.

16. ENVIRONMENTAL IMPACT

The Chemistry Project will be planned and executed in conformance with 1) NASA regulations entitled Environmental Quality (14 CFR Part 1216); 2) other relevant Federal environmental laws, regulations, and Executive Orders; and 3) NMI's addressing environmental issues.

17. SAFETY

An Chemistry Project safety program includes the assurance of system safety and the consideration of human factors in system man/machine interfaces.

17.1 INDUSTRIAL SAFETY

The safety procedures and requirements to be followed in implementing the Chemistry Project are in response to and in accordance with the policies and guidelines set forth in GSFC Health and Safety Program, GMI 1700.2C; Basic Safety Manual, NHB 1700.1 (V1-B); and the overall GSFC policy of avoiding injury to people and property loss to the maximum extent practical.

17.2 CONTRACTOR'S FACILITIES

Each of the Project's contractors will address their own safety and security in their facilities.

17.3 DATA SECURITY

The Chemistry Project will interface with the Center Security Office to ensure that its data security efforts are in compliance with NASA and GSFC requirements and standards.

17.4 REFERENCES

There are two documents which govern safety for all occupants of Building 16W:

- Building 16W Evacuation Plan
- Building 16W Health and Safety Plan

Copies of these plans may be obtained from the Building 16W Facility Operations Manager (FOM).

18. Technology Assessment and Commercialization

Technology transfer and commercialization begins with the identification and reporting of a new technology. This requirement comes from the NASA Administrator's technology guidelines as well as meeting the NASA - GSFC ISO 9001 compliance requirements. A new technology can be simply defined as any technology that is not "off-the-shelf" or that is not a service. All new technologies will be reported to the Technology Commercialization Office (TCO), Code 750.

New technology efforts funded by the Chemistry Project included: magnetic bearings for choppers (HIRDLS). However, new technology found in any mission element (spacecraft, science processing, ground system, and launch vehicle) will be reported to Code 750. Any new or unique product or process developed with project funds will be reported, independent of whether it is the result of civil servant or contractor efforts.

After receiving the new technology report, Code 750 will decide whether to initiate a market assessment from which market reports are generated. The market reports indicate the potential industrial users, and what the ideal form, fit, function, and cost should be to maximize commercialization. Finally, Code 750 determines if patent protection should be pursued, industrial users of the technology should be contacted, and if a technical brief article should be submitted.

19. REVIEWS

19.1 PROGRAM LEVEL REVIEWS

19.1.1 Independent Annual Review

The Chemistry Project reports to the NASA Headquarters Associate Administrator, Earth Science Enterprise once a year. The purpose of this review is to provide a validation of conformance to the PCA. The following items are covered at this review:

- Assessment of the progress/milestone achievements against the original baseline
- Review and evaluation of the cost, schedule, and technical content of the Project over its life cycle
- Assessment of technical progress, risks remaining, and mitigation plans
- Determination of any Project deficiencies that exist which result in revised projections exceeding the predetermined thresholds

19.2 PROJECT LEVEL REVIEWS

19.2.1 Management Coordination Review (MCR)

The Chemistry Project conducts a monthly review with the Director of Code 400 and the EOS Program Manager. The technical, schedule, and financial status of the Chemistry Project are presented.

19.2.2 Monthly Status Review (MSR)

The Chemistry Project holds a monthly review with the GSFC Center Deputy Director. The technical, schedule, and financial status of the Chemistry Project are presented.

19.2.3 Project Status Review (PSR)

This review is internal to the Chemistry Project. Each major area of the Project and the Project's primary contractors report to the Project Management Team. Significant events since last month's review; accomplishments; budget, technical, and schedule status; and issues are covered.

19.3 MISSION SYSTEMS REVIEWS

19.3.1 Spacecraft Reviews

Earlier a detailed requirements review, preliminary design review and critical design review were held for the EOS Common Spacecraft Bus, with the PM suite of instruments as the payload. During those reviews the CHEM implementation was also considered in terms of the changes that would have to be made to the Common Spacecraft Bus in order to accommodate the Chemistry payload. Due to the fact that the CHEM spacecraft will utilize the second build of the Common Bus, and also due to the earlier

reviews that dealt with the Chemistry accommodations, the upcoming CHEM specific reviews described below will benefit from this mature bus design.

19.3.1.1 Systems Requirements Review / Delta Preliminary Design Review (SRR/ Δ PDR)

A combined SRR/ Δ PDR will be conducted for the Chemistry spacecraft. The purpose of the Systems Requirements Review will be to ensure that the requirements meet the objectives of the Chemistry mission, will lead to a reasonable solution, and are consistent with the overall mission objectives. The Δ PDR will be held to demonstrate that the Common Spacecraft Bus design concepts meets CHEM system requirements with acceptable risk, that the overall system architecture has been established in terms of "kits" necessary to accommodate the CHEM instruments, and that the external interfaces have been identified.

19.3.1.2 Delta Critical Design Review (Δ CDR)

This review will occur after the design freeze (of kit hardware/software implementations) and before integration of flight components begins. The Δ CDR will emphasize final detailed implementations of the Common Bus design for the CHEM payload, and verify plans for flight systems, including the results of engineering model verification.

19.3.1.3 Pre-Environmental Review (PER)

This review will occur before environmental testing of the spacecraft of the spacecraft begins. The primary purposes of this review are to establish the readiness of the integrated flight system for test and to evaluate the environmental test plans.

19.3.1.4 Pre-Shipment Review (PSR)

This review will take place before shipment of the spacecraft to the launch site and will concentrate on system performance during acceptance testing.

19.3.2 Chemistry Instrument Reviews

The reviews required for the Chemistry instruments are described in the following sections.

19.3.2.1 Conceptual Design and Cost Review (CDCR)

This review occurred near the end of the definition and study phase; its purpose was to evaluate each instrument's design approaches and operational concepts.

19.3.2.2 Preliminary Design Review (PDR)

This review occurred relatively early in each instrument's design phase but before manufacture of engineering model hardware. Where applicable, it included the results of test bedding and breadboard testing, and simulation and/or prototyping for software.

19.3.2.3 Critical Design Review (CDR)

This review will occur after an instrument's design has been frozen but before major manufacturing of flight components begins. It will emphasize implementations of the design and verification plans for the instrument, including the results of engineering model verification.

19.3.2.4 Pre-Environmental Review (PER)

This review will occur before environmental testing of the protoflight or flight instrument begins. The primary purposes of the review are to establish the readiness of the instrument for test and to evaluate the environmental test plans.

19.3.2.5 Pre-Shipment Review (PSR)

This review will take place before the instrument is shipped to the spacecraft for integration and will concentrate on instrument performance during acceptance testing.

19.3.3 Mission Operations Review (MOR)

Approximately one year prior to each scheduled flight, a Mission Operations Review will be held to review the status of the system components, including the ground system and its operational interfaces with the flight system. Mission operations considerations for the flight instrument will be included. Discussions will also include integration and test planning.

19.3.4 Flight Operations Review (FOR)

Approximately 90 days prior to each flight, a Flight Operations Review will be held to determine the system's (flight and ground) readiness to support a safe and successful launch and subsequent flight operations. This review will present the results of tests, demonstrations, and analysis that demonstrate that the total system is ready to support the upcoming launch, that all necessary procedures are in place and verified, and that all operations personnel are trained and ready to support the mission.

19.3.5 Operational Readiness Review (ORR)

Within approximately 90 days of launch, an Operational Readiness Review will be held to examine the overall readiness to support the mission. The readiness of all ground hardware, software, personnel, procedures, and user documentation will be verified.

Appendix A

Acronyms and Abbreviations

AIRS	Atmospheric Infrared Sounder
AM	morning (ante meridian)
AO	Announcement of Opportunity
CCB	Configuration Control Board
CCSDS	Consultative Committee for Space Data Systems
CDR	Critical Design Review
CFR	Code of Federal Regulations
CHEM	Chemistry
cm	centimeter
COPI	Co - Principal Investigator
CPAF	Cost Plus Award Fee
CRM	Continuous Risk Management
CU	University of Colorado
DAAC	Distributed Active Archive Center
DPM	Deputy Project Manager
ELV	Expendable Launch Vehicle
EMOS	EOS Mission Operations System
EO-ICWG	Earth Observations International Coordination Working Group
EOS	Earth Observing System
EOS-G	GSFC's EOS Office
EOSDIS	Earth Observing System Data and Information System
EPPP	Execution Phase Project Plan
ESDIS	Earth Science Data and Information System
ESE	Earth Science Enterprise
FDS	Flight Dynamics System
FMI	Finnish Meteorological Institute
FOO	Flight of Opportunity
FOR	Flight Operations Review
FPD	Flight Projects Directorate
GAO	Government Accounting Office
GFE	Government Furnished Equipment
GIA	Government Inspection Agency
GMI	Goddard Management Instruction
GPG	GSFC Procedures and Guidelines
GPMC	GSFC Project Management Council
GSFC	Goddard Space Flight Center
GSOM	Ground Systems and Operations Manager
HIRDLS	High-Resolution Dynamics Limb Sounder
I&T	Integration and Test
ICD	Interface Control Document
ICESat	ICE Satellite

IELV	Intermediate Class Expendable Launch Vehicle
IEOS	International Earth Observing System
IG	Inspector General
IRD	Interface Requirements Document
ISM	Instrument Systems Manager
JPL	Jet Propulsion Laboratory (DAAC)
km	kilometer
m	meter
MAR	Mission Assurance Requirements
MCR	Monthly Coordination Review
MELV	Medium Class Expendable Launch Vehicle
MLS	Microwave Limb Sounder
MODIS	Moderate Resolution Imaging Spectroradiometer
MOR	Mission Operations Review
MOU	Memorandum of Understanding
MPS	Multi-Project Support
MSR	Monthly Status Review
MTPE	Mission To Planet Earth
NASA	National Aeronautics and Space Administration
NECR	National Environmental Research Council (UK)
NIVR	Netherlands Agency for Aerospace Programmes
NMI	NASA Management Instruction
NPG	NASA Procedures and Guidelines
OH	hydroxyl radical
OMI	Ozone Monitoring Instrument
ORR	Operations Readiness Review
PAR	Performance Assurance Requirements
PCA	Program Commitment Agreement
PCMB	Project Control Management Board
PDMP	Project Data Management Plan
PG	Procedures and Guidelines
PI	Principal Investigator
PM	afternoon (post meridian)
PM	Project Manager
POP	Program Operating Plan
ppbv	parts per billion by volume
ppmv	parts per million by volume
pptv	parts per trillion by volume
PSR	Project Status Review
ROS	Research Operations Support
SAM	System Assurance Manager
SCF	Science Computing Facility
SE&I	System Engineering and Integration
sr	steradian

TDRS	Tracking and Data Relay Satellite
TDRSS	TDRS System
TES	Tropospheric Emission Spectrometer
TOMS	Total Ozone Mapping System
U. S.	United States
UPN	Unique Project Number
USGCRP	U. S. Global Change Research Program
W	watts
WBS	work breakdown structure
WTR	Western Test Range

Appendix B

Applicable and Referenced Documents

NASA Program and Project Management Processes and Requirements, NPG 7120.5A

Project Management, GPG 7120.2

The NASA Policy for Limiting Orbital Debris, NPD 8710.3

Execution Phase Project Plan for Earth Observing Systems (EOS), 170-01-01

Environmental Quality (NASA Regulations), 14 CFR Part 1216

Configuration Control, 400-PG-8700.2.1

Mission Assurance Guidelines for Tailoring to the Needs of GSFC Projects, 300-PG-7120.2.2

Earth Observing System (EOS) Performance Assurance Requirements for EOS Common Spacecraft, 420-05-04

HIRDLS Mission Assurance Requirements, 424-11-13-01

OMI Mission Assurance Requirements, 424-11-13-03

TES/MLS Mission Assurance Requirements, 424-11-13-02

Earth Observing System Chemistry Project Continuous Risk Management (CRM) Plan, 424-PG-1720.2.2

GSFC Health and Safety Program, GMI 1700.2C

Basic Safety Manual, NHB 1700.1 (V1-B)

System Safety for Orbital Flight Projects, GMI 1700.3A

Western Range Regulation Range Safety Requirements, Western Range Regulation (WRR) 127-1

CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes
Baseline	April 15, 1999	Initial Release